FINAL REPORT

Assessment of Geology, Energy, and Minerals (GEM) Resources

SHEEPSHEAD MOUNTAIN GEM RESOURCE AREA

(OR-023-18)

HARNEY and MALHEUR COUNTIES, OREGON

Prepared for

United States Department of the Interior
United States Bureau of Land Management
Scientific Systems Development Branch

March 1983

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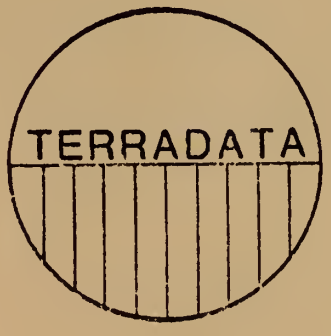

TERRADATA
7555 West 10th Avenue
Lakewood, CO 80215
(303) 237-7462

Assessment of Geology, Energy, and Minerals (GEM) Resources

Sheepshead Mountain GRA (OR - 023 - 18) Harney and Malheur Counties, Oregon

Prepared For:

United States Department of the Interior
United States Bureau of Land Management
Scientific Systems Development Branch

By

Geoffrey W. Mathews
William H. Blackburn
D. Lynne Chappell

TERRADATA

Bureau of Land Management Project Direction:

Jean Juilland, Project Manager, Scientific Systems Development Branch
Durga Rimal, COAR, BLM State Geologist, Oregon
Larry Steward, BLM State Geologist, Nevada
Ted Holland, BLM State Geologist, Idaho

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March, 1983

This report was prepared as part of a Phase I Assessment of GEM Resources within designated Wilderness Study Areas in Oregon, Idaho and Nevada.

TERRADATA
7555 West Tenth Avenue, Suite 200, Lakewood, Colorado 80215
303 - 237 - 7462

DISCLAIMER

This document is part of a report prepared under Contract Number YA - 553 - CT2 - 1042 for the United States Department of the Interior, Bureau of Land Management. Although officials of the Bureau of Land Management have provided guidance and assistance in all stages of the project, the contents and conclusions contained herein do not necessarily represent the opinions or policies of the Bureau.

ACKNOWLEDGEMENTS

The authors very much appreciate the information, interpretations, and comments made by many different people and organizations as part of the preparation of this report. Special recognition goes to Mr. Jean Juilland of the Bureau of Land Management's Scientific Systems Development Branch. As Project Manager, he has provided valuable guidance and insight in all phases of the project. Mr. Durga Rimal, BLM State Geologist for Oregon and the Contracting Officer's Authorized Representative (COAR), was very helpful in the successful completion of this project. His assistance and guidance is greatly appreciated. Mr. Larry Steward, BLM State Geologist for Nevada, and Mr. Ted Holland, BLM State Geologist for Idaho, served as Project Inspectors. Their assistance in procuring needed maps, aerial photographs, and helicopter transportation also is greatly appreciated.

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- Dr. Antonius Budding - Oil Shale and Tar Sands
- Mr. Raymond Corcoran - Field Verification
- Dr. James Firby - Paleontology
- Mr. Ralph Mason - Coal
- Mr. Richard Miller - Uranium and Thorium
- Mr. Vernon Newton - Oil and Gas
- Mr. Herbert Schlicker - Industrial Minerals and Geologic Hazards
- Dr. Walter Youngquist - Geothermal
- Dr. Paul Weis - Metals and Non - Metals.

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Technical assistance was provided by Mr. Frederic W. Lambie, Dr. Steve N. Yee and Dr. Terence L. Lammers of TERRADATA. Their assistance is most gratefully acknowledged.

Mr. Tom Mitchell assisted in the stream sediment sampling program. Bondar - Clegg provided the geochemical analysis of stream sediment samples.

Ms. Pamela Ruhl provided clerical and editorial assistance throughout the project. Ms. Sara Mathews assisted with occurrence information and drafting. Mr. Philip R. Jones and Mr. Michael A. Becker produced all documents relating to the project using TERRADATA's word processing and document production systems.

EXECUTIVE SUMMARY

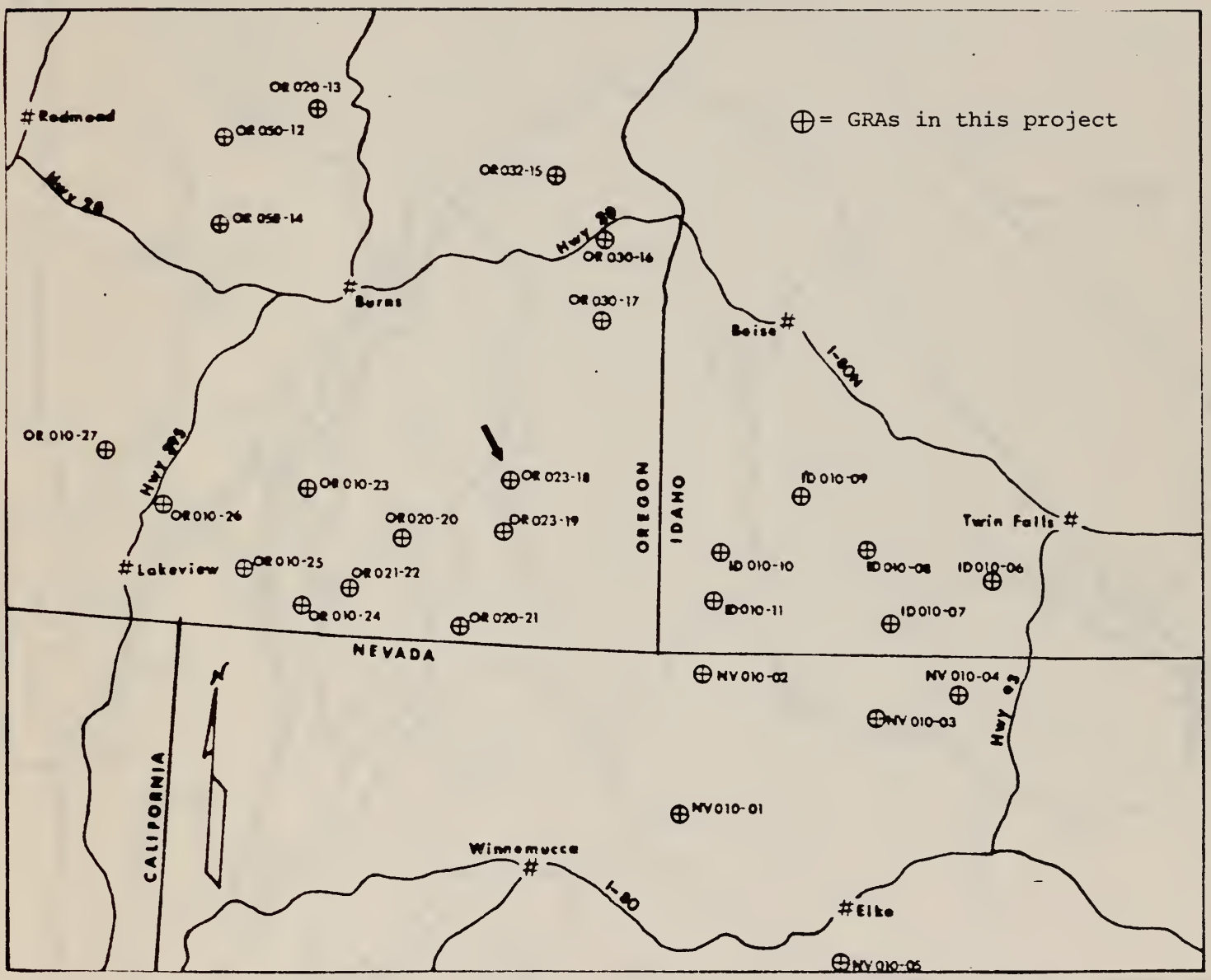
The purpose of this project is to evaluate and classify environments favorable for the occurrence of GEM resources in southeastern Oregon, southwestern Idaho, and northern Nevada. **(See the TERRADATA report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.")** GEM resource environments have been rated on a scale that ranges from one to four, with one being least favorable and four being most favorable. Favorability classes two and three represent low and moderate favorability, respectively. Confidence levels range from A to D with A being low confidence and D being high confidence. The confidence levels are directly related to the quantity and quality of the information available for the determination of the favorability classes.

The specific area with which this report deals is the Sheepshead Mountain GEM resource area (GRA OR-023-18) which is located in southeastern Oregon (see attached location map). The Sheepshead Mountain GRA contains about 630 square miles within Townships 29S through 33S and Ranges 35E through 39E. It contains nine WSAs; WSA 2-23L, WSA 2-23M, WSA 2-72C, WSA 2-72D, WSA 2-72F, WSA 2-72I, WSA 2-72J, WSA 2-73H, and WSA 3-114 which comprise 254,560 acres. The study area is in the Andrews and Southern Malheur Resource Areas of the Burns and Vale BLM Districts. It is about 50 miles from Burns, Oregon.

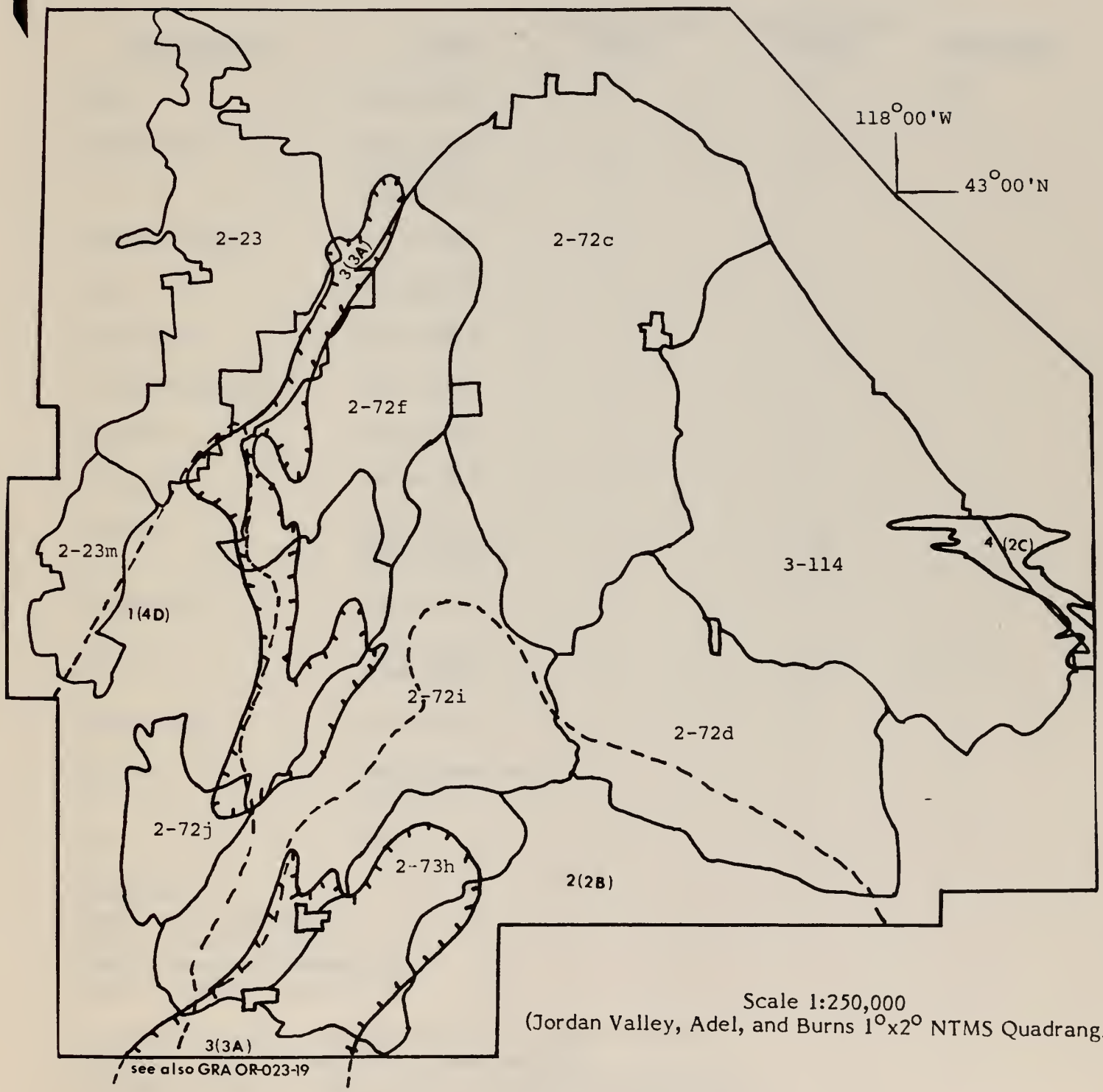
The Sheepshead Mountain GRA is within the Great Basin sub-province of the Basin and Range physiographic province. It is underlain by rocks that range from Paleozoic miogeoclinal sediments to Tertiary volcanics and volcaniclastic strata. No Pre-Tertiary rocks are exposed in the area. The area is west of the major structural Antler orogenic belt. Basin and Range fault blocks are common in the portion of Oregon.

The Sheepshead Mountain GRA contains several geologic environments that are variously favorable for GEM resources. A part of the study area is classified 4D for the occurrence of geothermal resources. The 4D rating signifies that the geologic environment, the inferred geologic processes, and the known deposits indicate high favorability for geothermal resources, and that the available data provide direct evidence and are quantitatively substantial to support the possible existence of this resource. The study area also contains a lacustrine environment that is moderately favorable for diatomite resources. A small alluvial area has a low (Class 2) favorability for fluorite.

GRA Location Map



Land Classification Map
Sheepshead Mountain GRA
(OR - 023 - 18)
Harney and Malheur Counties, Oregon



Scale 1:250,000
(Jordan Valley, Adel, and Burns 1°x2° NTMS Quadrangle)

Classification Of Lands Within The Sheepshead Mountain GRA (OR - 023 - 18) Harney and Malheur Counties, Oregon For GEM Resource Potential

COMMODITY	AREA	CLASSIFICATION LEVEL	CONFIDENCE LEVEL	REMARKS
Metals	Entire GRA	2	B	Hg
Geothermal	Area 1-4D	4	D	
	Area 2-2B	2	B	
	Rest of GRA	1	B	
Uranium/Thorium	Entire GRA	1	A	
Coal	Entire GRA	2	C	
Oil and Gas	Entire GRA	3	B	
Tar Sands/Oil Shale	Entire GRA	1	C	
Limestone	Entire GRA	1	B	
Bentonite	Entire GRA	2	A	
Diatomite	Ares 3-3A	3	A	
	Rest of GRA	1	B	
Clinoptilolite	Entire GRA	2	A	
Fluorite	Area 4-2C	2	C	
	Rest of GRA	1	B	
Paleontology	Entire GRA	2	A	
Hazards	See Hazards Map (GRA File)			
ESLs	None	1	C	

LEGEND:
Class 1 - Least Favorable
Class 2 - Low Favorability
Class 3 - Moderate Favorability
Class 4 - High Favorability

Confidence Level A - Insufficient data or no direct evidence
Confidence Level B - Indirect evidence available
Confidence Level C - Direct evidence but quantitatively minimal
Confidence Level D - Abundant direct and indirect evidence

The entire Sheepshead Mountain GRA is favorable (Class 2) for coal, oil and gas, bentonite, clinoptilolite, and paleontological resources (see table, above). The area does not exhibit characteristics favorable for other GEM resources.

TERRADATA recommends that further surface geologic investigations be undertaken in the Sheepshead Mountain GRA in order to increase confidence levels in the classifications. Detailed geologic mapping and geochemical investigations would be useful in upgrading the land classification of this area. Selective drilling of geochemical and/or geophysical anomalous areas would contribute to the refinement of the confidence levels and favorability ratings in this GRA.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Concluded)

Figures

Table

1. INTRODUCTION

This report is one of 27 GRA technical reports that summarize the results of a Phase I assessment of the geology, energy, and minerals (GEM) resources in selected portions of southeastern Oregon, southwestern Idaho, and northern Nevada. The study region was subdivided into 27 GEM resource areas (GRAs), principally for ease of data management and interpretation. The assessment of GEM resources for this project consisted of an interpretation of existing literature and information by experts knowledgeable in both the geographic area and specific commodities. A limited stream sediment sampling program also was conducted. It is possible that the assessment would be different if detailed field exploration, geochemical sampling, and exploratory drilling programs were undertaken. (See the TERRADATA report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.")

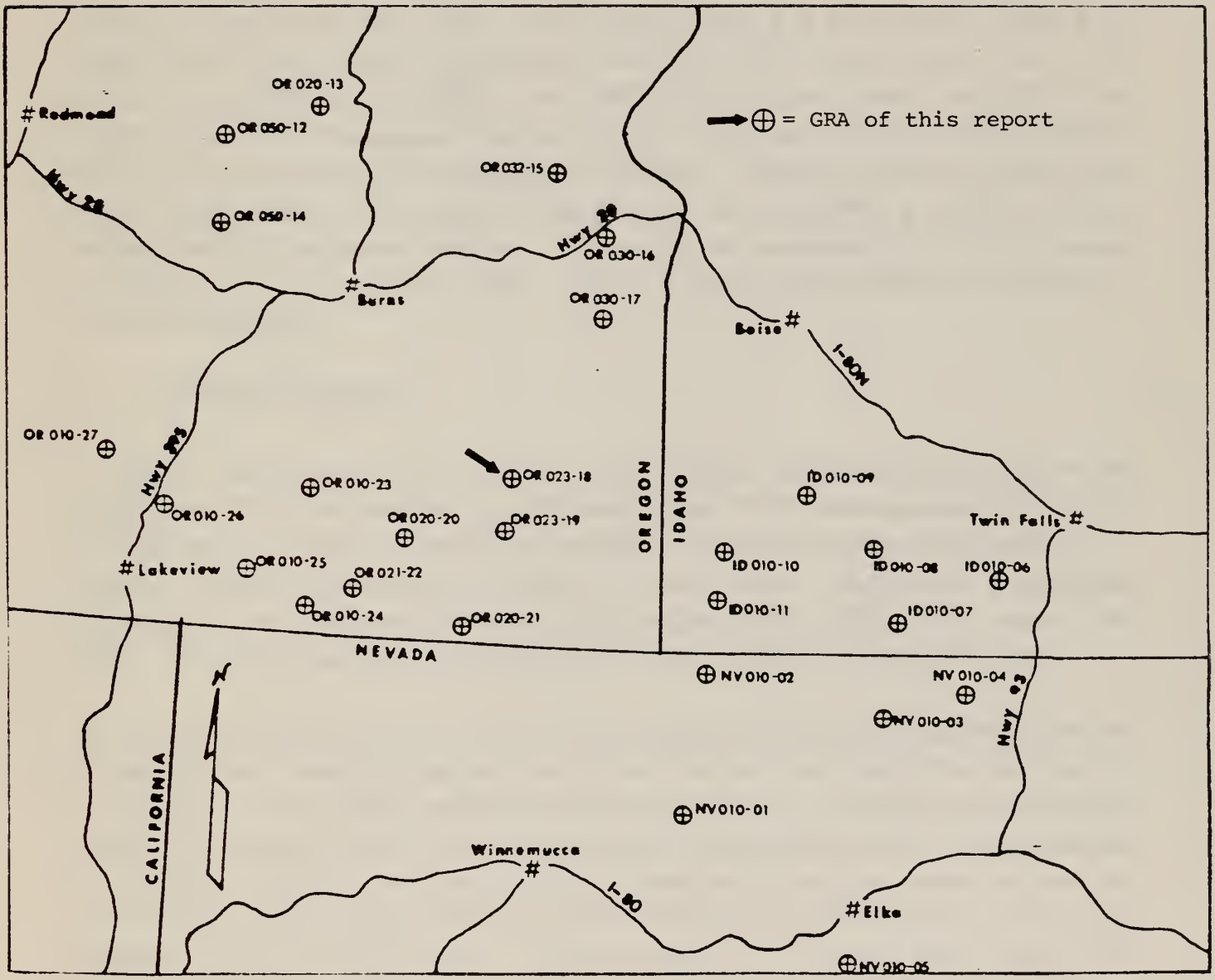
This report summarizes the assessment of the GEM resources potential of the Sheepshead Mountain GRA (OR-023-18). See Figure 1-1. Commodity categories for which this GRA was evaluated are:

- Metals
- Oil and Gas
- Oil Shale and Tar Sands
- Geothermal
- Uranium and Thorium
- Coal
- Industrial Minerals
- Paleontological Resources
- Geologic Hazards
- Educational and Scientific Localities (ESLs)

Geologic environments within the Sheepshead Mountain GRA have been rated with respect to their favorability for the occurrence of these different commodities. The favorability rating scale ranges from one to four, with one being least favorable and four being most favorable. Confidence levels in these ratings also have been assigned. These confidence levels range from A to D, with A being low confidence and D high confidence. Assigned confidence levels are related to the quantity and quality of the information available for the determination of the favorability ratings.

FIGURE 1-1

GRA Location Map



2. DESCRIPTION OF THE SHEEPSHEAD MOUNTAIN GRA

2.1 LOCATION

The Sheepshead Mountain GRA (OR-023-18) is in southeast Oregon. It lies between latitudes 42°40'N and 43°05'N and longitudes 117°55'W and 118°30'W. The Sheepshead Mountain GRA contains approximately 630 square miles within Townships 29S through 33S and Ranges 35E through 39E (see Figures 1-1 and 2-1). The area contains nine Wilderness Study Areas (WSAs); WSA 2-23L (21,000 acres), WSA 2-23M (8,090 acres), WSA 2-72C (54,190 acres), WSA 2-72D (35,000 acres), WSA 2-72F (20,330 acres), WSA 2-72I (38,855 acres), WSA 2-72J (7,755 acres), WSA 2-73H (14,640 acres), and WSA 3-114 (54,700 acres). The Sheepshead Mountain GRA is in the Andrews and Southern Malheur Resource Areas of the Burns and Vale BLM Districts. The area is about 50 miles from Burns, Oregon which is the nearest transportation center offering a minimum of rail, highway, and/or charter-air services. Access to the contained WSAs is via county maintained dirt or packed-gravel roads. Vehicular access to the interior of the WSAs is poor to non-existent.

2.2 GENERAL GEOLOGY

The Sheepshead Mountain GRA is in the Jorden Valley, Adel, and Burns 1°x2° NTMS Quadrangles. The data available for this area include NURE investigations[1, 2, 3, 4, 5, 6, 7, 8]*, general mineral resource information[9], and small scale geologic mapping[10]. Detailed geologic information is lacking in most areas. Occurrence information evaluated for the Sheepshead Mountain GRA includes MILS, CRIB, NURE, claims, and leases. The overall quantity and quality of commodity specific information is poor.

The Sheepshead Mountain GRA is within the northern section of the Great Basin portion of the Basin and Range physiographic province. The Basin and Range Province consists of generally north-trending fault-block mountains separated by parallel intermontane basins. The mountain blocks are commonly ten to twelve miles wide and are separated by alluviated valleys of comparable width. Elevation ranges from below sea-level at Death Valley to more than 13,000 feet at White Mountains Boundary Peaks. Local relief generally is less that 5,000 feet. The physiography of the Great Basin reflects the structural and lithologic complexity of the underlying bedrock. The Great Basin portion of the Basin and Range Province extends from southern Nevada northward into southern Oregon. The northern-most extremity is located just north of the town of Burns, Oregon.

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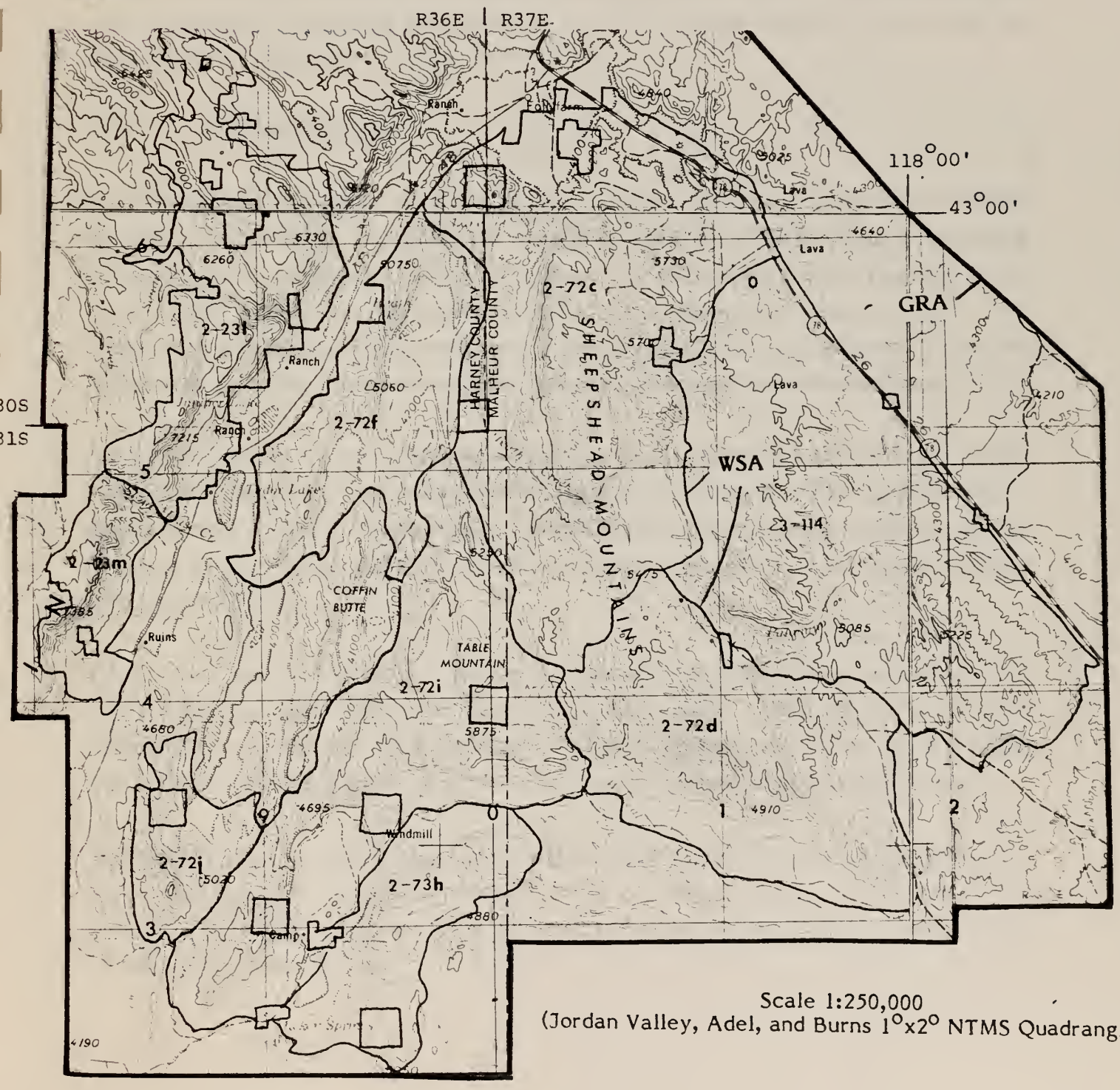
* In this report, citations are superscripted numbers. They refer to bibliographic entries listed in Appendix A, References Cited.

FIGURE 2-1

Topographic Map
Sheepshead Mountain GRA
(OR-023-18)
Harney and Malheur Counties, Oregon



Scale 1:250,000
(Jordan Valley, Adel, and Burns 1°x2° NTMS Quadrangle)

The part of the Basin and Range Province that lies in southern Oregon extends eastward from the Cascade Range to the eastern limits of the Trout Creek Mountains. This part of the Province is dominantly underlain by Cenozoic volcanic strata. Pre-Tertiary rocks are exposed in only two places in the Oregon part of the Basin and Range Province; in the Pueblo Mountains and in the Trout Creek Mountains of southeastern Harney County. Very little is known about the Pre-Tertiary basement in this area. A sparse amount of data is available regarding the depth to the Pre-Tertiary basement rocks and the thickness and nature of the Tertiary cover rocks.

2.2.1 Geomorphology

The Sheepshead Mountain GRA is at the northern end of the Basin and Range Physiographic Province. It consists of a series of north-trending fault-block mountains, with intervening, steep-sided valleys. A long, narrow valley with internal drainage trends northeasterly across the northmost corner of the Sheepshead Mountain GRA. Its orientation, longitudinal persistence, and the occurrence of hot springs indicate that this is a fault-line valley. The governing structure may have significant displacement.

The central portion of the Sheepshead Mountain GRA consists of a series of lava capped buttes and mesas and the prominent Sheepshead Mountains. This central area is predominantly in slope. It contains several high-altitude ephemeral lakes and playas. Drainage in the central region is not well developed, but exhibits a radial pattern around Sheepshead Mountain.

The southern part of the area is marked by a broad valley that trends transverse to the major structural grain of the Sheepshead Mountain GRA. Although it is currently occupied by several intermittent streams, it has the geomorphic character of a valley that was excavated by a much larger volume of water (perhaps during Pluvial times).

The highest point in the Sheepshead Mountain GRA is near the western margin of the area, 7,500 feet, and the lowest point is along the eastern margin, 4,000 feet. Local relief is as much as 3,000 feet along the fault scarp that borders the major valley in the northwestern part of the area.

2.2.2 Lithology and Stratigraphy

Paleozoic and Mesozoic units may occur at undetermined depths in the Sheepshead Mountain GRA because this area is within the margins of both the western Triassic and the western Late Paleozoic depositional basins[11]. None of these units however, are exposed in or near the area. Tertiary basalt flows are the oldest rocks exposed in the Sheepshead Mountain GRA (Figure 2-2).

The majority of rocks in this GRA are Tertiary volcanogenic strata and Quaternary alluvium and colluvium. The Tertiary volcanic rocks comprise basalts, andesites, and silicic flows, tuffs, and ash-flow tuffs. Basaltic and andesitic rocks underlie most of the Sheepshead Mountain GRA. These rocks are probably related to the widespread calc-alkalic volcanism associated with subduction along the Pacific margin, which produced mostly andesitic to rhyolitic rocks.

Representatives of a second Tertiary volcanic group, Mid-Miocene dacitic to rhyolitic flows ash-flow tuffs, occur throughout the Sheepshead Mountain GRA. Some of these rocks are peralkaline or have peralkaline affinities. They are related to the beginning of extensional tectonics in the area. Associated with the second Tertiary volcanogenic episode is a series of tuffaceous fluvio-lacustrine shales, mudstones, sandstone, conglomerates, and fanglomerates. Air-fall tuff and diatomaceous sedimentary rocks also may occur.

A third volcanic group consists mostly of Middle to Late Miocene olivine basalt flows. These rocks are correlative with the flood basalts of the Columbia River Plateau Province. Relatively young basalt flows and other volcanic ejecta occur in the northern and southeastern parts of the Sheepshead Mountain GRA.

Quaternary exogenous domes, flows, and flow breccias of rhyodacitic composition occur in parts of the Sheepshead Mountain GRA. A small amount of Late Pleistocene or Recent basalt also occurs in parts of the area.

FIGURE 2-2

Geologic Map
Sheepshead Mountain GRA
(OR-023-18)
Harney and Malheur Counties, Oregon

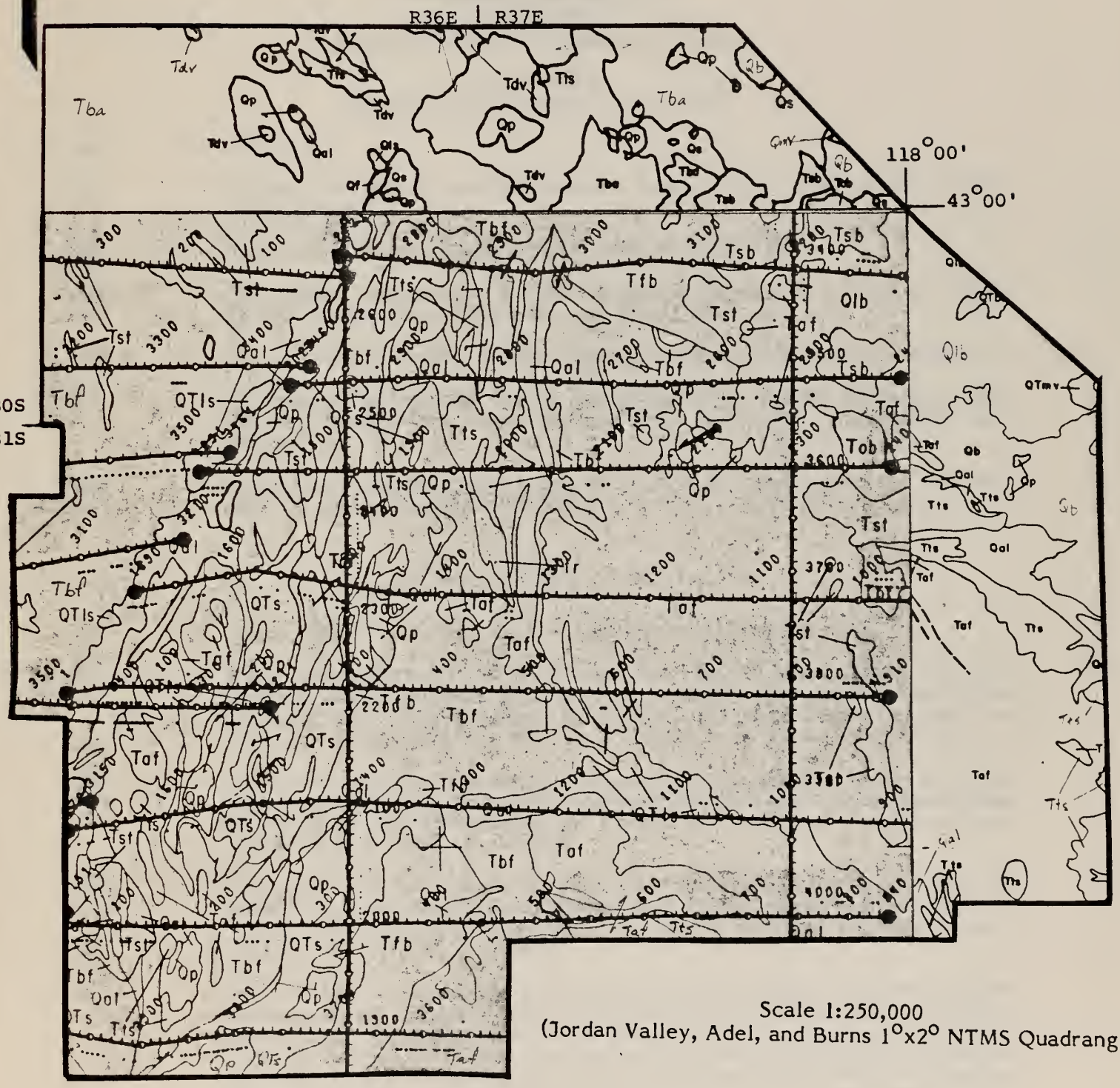


FIGURE 2-2
(Continued)

Geologic Map Legend For
Sheepshead Mountain GRA
(OR-023-18)
Harney and Malheur Counties, Oregon

Jordan Valley
(South of 43°00' and East of 118°00')

Qal - Alluvium

Qb - Sedimentary Rocks and Interbedded Basalt Flows: Feldspatic, olivine-bearing basalt.

Qlb - Thin Basalt Flows Correlate with Snake River Group

QTba - Tuffaceous Sedimentary Rocks, Palagonite Breccia and Tuff, and Mafic Flows: Diktytaxitic, olivine-bearing basalt flows.

QTmv - Rocks of Mafic Vents: Basaltic and andesitic breccia, scoria, and flows.

Tts - Tuffaceous Sedimentary Rocks, Tuffs, and Silicic Flows: Fine-graind tuffaceous sedimentary rocks representing flood plain and shallow lake deposits.

Taf - Flows and Flow Breccias: Andesite flows, with minor basalt and interbedded tuff and tuffaceous sediments.

Adel
(South of 43°00', and West of 112°00')

Qp - Playa Deposits: Recent clay, silt, sand, and some evaporites.

Qlb - Late Basalt Flows: Late Pleistocene or Recent. Thin flows of olivine-bearing, diktytaxitic basalt. Commonly highly fledspathic. Upper flow surfaces show little evidence of erosion. Pressure ridges, tumulo, and elongate depressions, representing collapsed laval tubes, are common.

Qal - Alluvium: Pleistocene-aged, un-consolidated fluviatile gravel, sand, and silt. In places, includes talus, slope-wash, fanglomerate, some small areas of exhumed Late Pleistocene and Recent lake beds, and wind-blown sand. Large areas of wind-blown sand.

QTls - Landslide Debris: Predominantly Pleistocene in age, although probably includes Pliocene and Recent. Mostly unstratified mixtures of basaltic and tuffaceous sedimentary bedrock. In places, includes disordered fault-blocks, basalt rubble, and talus.

QTs - Lacustrine, Fluviatile, and Aeolian Sedimentary Rocks: This unit contains interstratified tuff, ashy diatomite, and unconsolidated clay, sand, silt, and gravel. Includes some small masses of hot spring sinter and tufa. Mostly confined to Pluvial lake basins. Correlative, in part, to Pliocene and Pleistocene water-laid volcanic deposits and Pleistocene non-marine terrace deposts. Larger areas of lacustrine gravels, principally in the form of deltas, bars, spits, and terraces.

FIGURE 2-2
(Continued)

Geologic Map Legend For
Sheepshead Mountain GRA
(OR-023-18)
Harney and Malheur Counties, Oregon

Jordan Valley
(South of 43°00' and East of 118°00')

Qal - Alluvium

Qb - Sedimentary Rocks and Interbedded Basalt Flows: Feldspatic, olivine-bearing basalt.

Qlb - Thin Basalt Flows Correlate with Snake River Group

QTba - Tuffaceous Sedimentary Rocks, Palagonite Breccia and Tuff, and Mafic Flows: Diktytaxitic, olivine-bearing basalt flows.

QTmv - Rocks of Mafic Vents: Basaltic and andesitic breccia, scoria, and flows.

Tts - Tuffaceous Sedimentary Rocks, Tuffs, and Silicic Flows: Fine-graind tuffaceous sedimentary rocks representing flood plain and shallow lake deposits.

Taf - Flows and Flow Breccias: Andesite flows, with minor basalt and interbedded tuff and tuffaceous sediments.

Adel
(South of 43°00' and West of 112°00')

Qp - Playa Deposits: Recent clay, silt, sand, and some evaporites.

Qlb - Late Basalt Flows: Late Pleistocene or Recent. Thin flows of olivine-bearing, diktytaxitic basalt. Commonly highly fledspathic. Upper flow surfaces show little evidence of erosion. Pressure ridges, tumulo, and elongate depressions, representing collapsed laval tubes, are common.

Qal - Alluvium: Pleistocene-aged, un-consolidated fluviatile gravel, sand, and silt. In places, includes talus, slope-wash, fanglomerate, some small areas of exhumed Late Pleistocene and Recent lake beds, and wind-blown sand. Large areas of wind-blown sand.

QTls - Landslide Debris: Predominantly Pleistocene in age, although probably includes Pliocene and Recent. Mostly unstratified mixtures of basaltic and tuffaceous sedimentary bedrock. In places, includes disordered fault-blocks, basalt rubble, and talus.

QTs - Lacustrine, Fluviatile, and Aeolian Sedimentary Rocks: This unit contains interstratified tuff, ashy diatomite, and unconsolidated clay, sand, silt, and gravel. Includes some small masses of hot spring sinter and tufa. Mostly confined to Pluvial lake basins. Correlative, in part, to Pliocene and Pleistocene water-laid volcanic deposits and Pleistocene non-marine terrace deposts. Larger areas of lacustrine gravels, principally in the form of deltas, bars, spits, and terraces.

FIGURE 2-2
(Continued)

Geologic Map Legend For
Sheepshead Mountain GRA
(OR - 023 - 18)
Harney and Malheur Counties, Oregon

, Adel
(South of 43°00' and West of 112°00')
(Continued)

Tsb - Tuffaceous Siltstone, Sandstone, Conglomerate Tuff, and Interbedded Basalt or Andesite Flows: The strata are flat to gently dipping. In Places, the unit contains Pliocene mammalian fossils. May intertongue with the upper part of unit Tb. Locally, the unit is subdivided into units Tsf and Tob.

Tst - Semi-Consolidated Lacustrine Tuffaceous Sandstone and Siltstone, Ash and Ashy-Diatomite, Conglomerate and Minor Fanglomerate, Boulder-Bearing Slope-Wash, Vitric-Crystal and Vitric-Lithic Tuff, Pumice Lapilli Tuff, and Tuff Breccia: Several of the tuffs in the northwestern and west-central portions of the map area are partly to densely welded and locally show much gas-phase alteration and extensive layers of spherulites. A potassium-argon age date of 9.7 million years was determined for the unit, based on welded tuff near the base of the unit.

Tob - Thin, Vesicular, Subophytic to Intergranular, Diktytaxitic Basalt Flows: Grey to black in color. contain small to moderate amounts of olivine that is either unaltered or slightly altered to iddingsite. Flows locally consist of platy olivine-bearing andesite or basaltic-andesite.

Tts - Fine-Grained, Tuffaceous Sedimentary Rocks and Tuffs: Late Miocene to early Pliocene in the western portion of the map area. This unit represents either a floodplain or a shallow lake deposit. More abundant, lake-bed layers are found in the southeastern portion of the map, and these include interlayers of ashy-diatomite with localized fish and plant fossils.

Tfb - Basalt and Andeiste Flows and Flow Breccias: Middle(?) and Late Miocene, the rock types in this unit are variable in texture and mineral composition. There are minor interbeds of tuffaceous sedimentary rocks, tuff, scoria, and localized layers of silicic volcanic rock near the top of the unit. Potassium-argon ages of 14.6 million years and 14.7 million years. Includes the Steens Basalt, Steens Mountain Volcanic Series, and an andesitic unit that overlies the Steens Basalt. In places unit Tfb is subdivided into units Taf and Tbf.

Taf - Platy Andesite Flows: Contains some flows of porphyritic olivine basalt, basaltic and andesitic flow breccias, and minor amounts of interbedded tuffaceous sedimentary rocks and tuff. Some localized layers of silicic (dacitic?) tuffs, breccias, brecciated flows(?). The texture of the andesite flows is commonly pilitazitic. Some are hyalopilitic to intersertal. Rocks low in the unit are generally altered and contain small to moderate amounts of montmorillonite. Glass in the groundmass is fresh to slightly altered in andesite flows near the top of the unit. The upper part of the unit includes the Steens Mountain Andesitic Series.

FIGURE 2-2
(Concluded)

Geologic Map Legend For
Sheepshead Mountain GRA
(OR - 023 - 18)
Harney and Malheur Counties, Oregon

Adel
(South of 43°00' and West of 112°00')
(Concluded)

Tbf - Massive Basalt Flows and Minor Interbeds of Tuff and Scoria: A few flows are uniformly fine-grained with pilotaxitic texture. Most are subophytic or diktytaxitic, and may are porphyritic. Plagioclase (An 60-70) is the dominent phenocryst in the porphyritic phases. Many flows, particularly those that are high in the section, are highly feldspathic. Most flows contain small to moderate amounts of olivine commonly altered to montomorillonite or illite or to iddingsite. Mafic glass, present in some flows, are generally altered to montomorillonite and illite. Pore spaces and fractures in some flows low in the section are filled with fibrous calcite (aragonite?), with crystalline to earthy or finely-granular white calcite, or with chabazite, analcite, natrolite, stilbite, and other zeolites. In the thickest portion of the unit, a very widespread lens, or a series of attenuated layers show both a conformable (interfingering) and an unconformable relationship with unit Taf. Includes the Steens Basalt and is correlative, in part, with the Warner and Columbia River basalts.

Burns
(North of 43°00' and West of 118°00')

Qp - Playa Deposits

Qal - Alluvium

Qf - Alluvial-Fan Deposits

Qs - Sedimentary Deposits

Qb - Basalt

Qls - Landslide Deposits

Qmv - Mafic Vent Complexes

Tsb - Tuffaceous Sedimentary Rocks, Basalt, and Welded Tuff

Tob - Tuffaceous Sedimentary Rocks, Basalt, and Welded Tuff: Basalt

Tdv - Welded Tuff of Devine Canyon

Tts - Tuffaceous Sedimentary Rocks

Tba - Basalt and Andesite

 - Fault (dashed where inferred).

 - Geologic contact (dashed where inferred).

2.2.3 Structural Geology

The tri-state area of northeastern Nevada, southern Oregon, and southwestern Idaho is characterized by several major structural elements. During the Early Paleozoic this area was the site of marine sedimentation in the north-northeast trending Cordilleran geosyncline. Sedimentation persisted in three sub-parallel belts until the end of the Devonian Period. One sedimentation belt was located in the eastern half of Nevada and received nearshore to littoral deposits of shallow-water carbonates with a minor amount of interbedded shale and sandstone. The second sedimentation belt was in the western half of the state and was the locus of transitional, progressively deeper water deposits. The third belt, located further west, was the site of eugeoclinal deposits.

In Late Devonian time, the Antler Orogeny developed along a north-northeast trending swath through northwest Elko County, Nevada, and on into southwestern Idaho. The Sheepshead Mountain GRA lies west of the axis of the Antler orogenic belt. As a direct result of the Antler orogenic uplift, a Pennsylvanian clastic wedge developed along the margins of the uplift. The orogeny culminated in a period of extensive thrust faulting that includes the Roberts' Mountain thrust.

The Sonoma Orogeny occurred in the Permian in north-central Nevada[11]. This deformational episode included more thrust faulting south of the Sheepshead Mountain GRA.

Another structural episode in this area was Basin and Range block faulting in response to extensional forces. Structures within the Sheepshead Mountain GRA are directly a function of the Basin and Range taphrogenic episode. North-trending normal faults are abundant in the area. Numerous linears have been detected and identified from aerial photographs and LANDSAT imagery[12]. Many of these linears may be fault structures. Some of the faults in this area may have displacement of up to 1,000 feet.

2.2.4 Paleontology

Tuffaceous lacustrine deposits and fluvial sandstones and siltstones are lithologically suited for fossil preservation[13]. Pliocene fossil mammals have been reported from these lithologies, although not from within the Sheepshead Mountain GRA.

2.2.5 Historical Geology

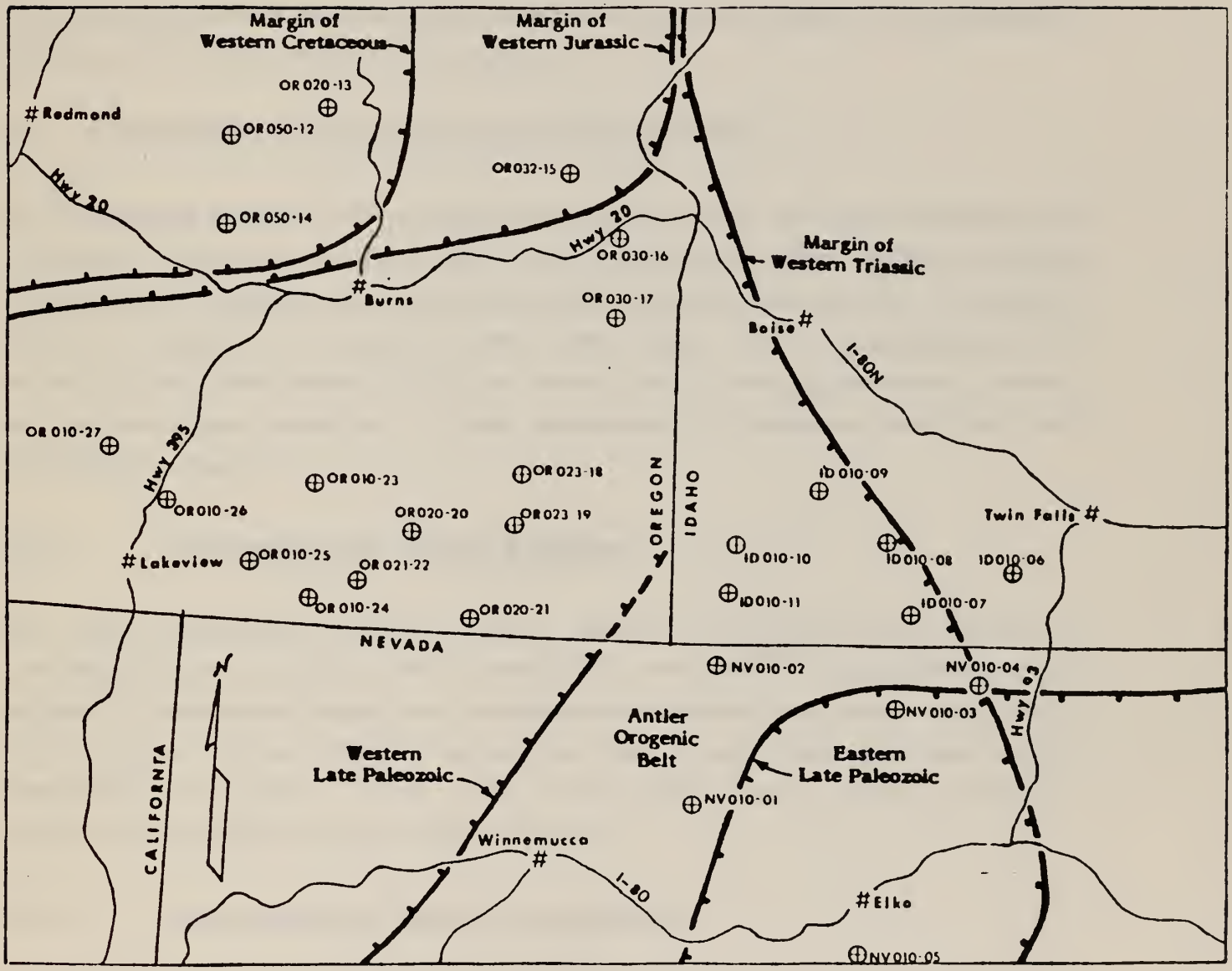
The present geologic character of the Great Basin resulted from the progressive development of the western portion of the North American continent throughout geologic time. Beginning in the Late Precambrian and continuing into the Middle Paleozoic, eastern Nevada, western Utah, southwesternmost Idaho were characterized by a miogeoclinal environment in which shelf margin carbonates, shales, and sandstones were deposited. In contrast, western Nevada and southern Oregon were in a eugeoclinal environment in which dark shales, radiolarian cherts and basaltic materials (Steinman's Trinity) were formed.

The Middle Paleozoic (Late Devonian-Early Mississippian) Antler Orogeny deformed and thrust the eugeoclinal sediments over the shelf-type sediments to the east, resulting in a north-trending highland in Central Nevada. A vast amount of fine-grained detritus was shed eastward during the Mississippian, producing thick upper Paleozoic shales in eastern Nevada and western Utah. Erosion of the Antler Highlands resulted in the deposition of coarse sediments during the Early Pennsylvanian. Some of these sediments may be present at depth in the Sheepshead Mountain GRA. Thousands of feet of sandstone and conglomerate were deposited in northern Nevada arond the margins of the Antler Highlands. Late Pennsylvanian and Permian shallow water sediments overlapped and overstepped the roots of the eroded highlands. Sediments deposited over the eroded Antler Highlands in the Permian were predominantly of the deep-water variety. The next significant tectonic episode (the Sonoma Orogeny) thrust the ocean floor siliceous and volcanic materials eastward over the shallow water, clastic sedimentary rocks that covered the ancient Antler Highland.

Development of western North American in the Mesozoic was dominated by oceanic plate subduction along the continental margin that resulted in a complex history of concomittant sedimentation, deformation, and igneous activity. During this time, the well-defined overthrust belt that extends from Canada to Mexico was formed. This deformation occurred during the Sevier (Late Jurassic to Latest Cretaceous) and Laramide orogenies (Latest Cretaceous to Early Tertiary Eocene).

FIGURE 2-3

Paleogeographic Map[11]
Oregon-Idaho-Nevada
Tri-State Area



Widespread silicic volcanic rocks formed in the Great Basin in Early and Middle Cenozoic time (primarily 20-34 million years ago). During Late Cenozoic time volcanic activity of the Great Basin changed to a bimodal basalt-rhyolite assemblage that reflects the taphrogenic character of the region. It was also during this time that the tectonic character of the region changed from one of compression to one of extension and led to the development of the Basin and Range structure. Quaternary basalts in the Sheepshead Mountain GRA may be related to this episode.

2.3 ENVIRONMENTS FAVORABLE FOR GEM RESOURCES

The Sheepshead Mountain GRA contains several environments that are favorable for the occurrence GEM resources. The area contains one environment that is highly favorable for geothermal resources and one that has a low favorability for geothermal resources. Moderate favorablity for diatomite exists in one mapped unit. Low favorbility exists across the Sheepshead Mountain GRA for metals, coal, oil and gas, bentonite, zeolites, and paleontological resources. A small environment in Quaternary rocks has a low favorbility for fluorite.

2.3.1 Environments for Metals Resources

The entire Sheepshead Mountain GRA is underlain by Tertiary and Quaternary volcanogenic rocks that have a low favorability for mercury[14]. Similar rocks in other regions in southwestern Oregon have occurrences of mercury. No evidence exists within the Sheepshead Mountain GRA, however, other than suitable host rocks, that suggest favorability for mercury. On the basis of the available data, no other environment appear to be favorable for other metallic resources.

2.3.2 Environments for Oil and Gas Resources

The Sheepshead Mountain GRA has a low favorability for potential oil and gas resources. Potentially favorable sub-surface environments include western Triassic and western Late Paleozoic formations, and Miocene Lake Bruneau units[11]. Prospective environments are overlain by Tertiary volcanics, therefore, all of the evidence is indirect. If the environments favorable for the accumulation of oil and gas do exist, then the associated Basin and Range faults might provide essential structural traps.

2.3.3 Environments for Oil Shale and Tar Sands Resources

The Sheepshead Mountain GRA contains no environments favorable for the occurrence of oil shale or oil impregnated sand[15]. The area is underlain predominantly by Tertiary volcanics. Potential sedimentary hosts are largely tuffaceous and contain only minor amounts of non-volcanic clastic material and carbonates. Favorable lithologies are not present.

2.3.4 Environments for Geothermal Resources

The southwestern portion of the Sheepshead Mountain GRA is a lowland area in which young volcanic rocks and fault zones occur. This locale has one known hot spring area called Mickey Hot Srpings. Numerous shallow bore-holes and geophysical surveys within this area indicate the possible existence of high-quality geothermal resources. Immediately southwest of this first area is another lowland region that has the same geologic attributes as the first. It too, is favorable for geothermal resources, although no surface manifestations are known[16].

2.3.5 Environments for Uranium and Thorium Resources

There are no environments favorable for the occurrence of uranium or thorium resources in the Sheepshead Mountain GRA[17]. Favorable source rocks, potential reductants, and evidence of inferred geologic processes of mineralization are all lacking in this study area.

2.3.6 Environments for Coal Resources

The Sheepshead Mountain GRA contains low favorability for the occurrence of coal and lignite deposits[18]. The chances for coal or carbonaceous materials to have formed in the Sheepshead Mountain GRA are remote. The geology of the Sheepshead Mountain GRA region does not support environments favorable for the formation of coal deposits. The area is underlain or is mantled with accumulations of highly tuffaceous sediments and related volcanic products. There is no evidence to support the inference that a coal-forming environment existed within the Sheepshead Mountain GRA.

2.3.7 Environments for Industrial Minerals Resources

Lacustrine sedimentary units within the Sheepshead Mountain GRA are moderately favorable for the occurrence of diatomite. Diatoms occur in tuffaceous lake sediments, but no concentrations of diatomite have been reported[12]. Bentonite may have formed within the Sheepshead Mountain GRA by the chemical alteration of volcanic-ash beds. Sufficient source rocks are present, but it cannot be demonstrated that the alteration proccess has occurred. Similarly, tuffaceous lacustrine sediments occur throughout the area. Diagenesis could produce zeolites (clinoptilolite). Although the area must be regarded as potentially favorable for zeolites because of the source rocks, the diagenetic processes cannot be demonstrated.

Fluorite has been reported in alluvium 18 miles east of the Sheepshead Mountain GRA. Similar alluvial deposits occur within the GRA. By analogy, they are considered favorable for the occurrence of fluorite.

2.3.8 Environments for Paleontological Resources

The GRA contains fluvial and lacustrine deposits that are similar to rock units elsewhere that contain a wide variety of flora and fauna. Similar rocks outside the GRA contain mammalian and reptilian vertebrate fossils. Although there are no known fossil occurrences in the Sheepshead Mountain GRA, favorable lithologies are present for this resource[13].

2.3.9 Environments for Geologic Hazards

Potential geologic hazards in the Sheepshead Mountain GRA consist of mapped and interpreted faults, landslides, and volcanic centers[12]. These features were noted from aerial photographs, geologic maps, and topographic maps. There is no historical record of violent seismic or volcanic activity the area. The potential for mass movement exists along all over-steepened slopes within the GRA.

2.3.10 Educational and Scientific Localities

There are no known ESLs in the Sheepshead Mountain GRA.

3. ENERGY AND MINERAL RESOURCES IN THE SHEEPSHEAD MOUNTAIN GRA

The Sheepshead Mountain GRA contains an environment that is highly favorable for geothermal resources, an environment that is moderately favorable for diatomite resources, and several environments that have a low favorability for metals (mercury), geothermal, coal, oil and gas, fluorite, bentonite, zeolite (clinoptilolite), and paleontological resources.

3.1 KNOWN DEPOSITS

The Sheepshead Mountain GRA has no known deposits.

3.2 OCCURRENCES

The Sheepshead Mountain GRA does not contain any CRIB, MILS, or NURE-related occurrences. Schlicker[12] reports the occurrence of diatoms in ashy lakebed sediments; no diatomite occurrences are known within the Sheepshead Mountain GRA, however.

3.3 CLAIMS

There are no claims recorded in the Sheepshead Mountain GRA as of 15 August, 1982.

3.4 LEASES

Most of the western half of the Sheepshead Mountain GRA is either leased or is under lease application for oil and gas (as of 15 August 1982). Some of this leasing activity is for geothermal resources.

3.5 DEPOSIT TYPES

There are no known deposits within or near the Sheepshead Mountain GRA. Expected deposit types are:

- Mercury; vein, replacement
- Geothermal; high-temperature
- Fluorite, alluvial
- Diatomite, bentonite, and zeolite, stratiform.

3.6 MINERAL ECONOMICS

Commodities for which the Sheepshead Mountain GRA is considered moderately favorable include geothermal resources and diatomite.

3.6.1 Geothermal

Geothermal resources may be classified into two general categories; low-temperature resources (96°F to 196°F), and high-temperature resources (196°F to 302°F). Uses of low-temperature geothermal resources include local industrial, agricultural, and domestic heating applications. High-temperature geothermal resources currently are used only in limited commercial electrical generation and research applications. Supply, demand, and price data are not established for this resource because of the limited amount of production. The importance of geothermal resources is generally of a local nature[16].

3.6.2 Diatomite

Diatomite is used primarily as a filter-aid, as an industrial filler, and other miscellaneous applications, including insulation[19]. Diatomite was produced by seven companies in four states in 1981[20]. California accounted for more than 50 percent of total diatomite production. The United States is the largest world producer and consumer of diatomite. The United States also is a net exporter of this commodity. Demand for diatomite is expected to increase at an annual rate of three percent through 1990. World resources of diatomite are adequate for the foreseeable future, but the need for near-market sources will encourage development of new sources.

3.7 STRATEGIC AND CRITICAL MINERALS AND METALS

Mercury is the only strategic commodity for which the Sheepshead Mountain GRA is considered potentially favorable. (See Table 3-4 in TERRADATA's report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.") The entire Sheepshead Mountain GRA has a low classification for mercury.

4. CLASSIFICATION OF LAND FOR GEM RESOURCES POTENTIAL

The precise location of specific favorable environments within a given GRA depends upon three principal factors:

- o The precision and specificity of avaliable data;
- o The nature (size and spatial distribution) of anticipated deposits as predicted from known models; and
- o The geometry of the favorable geologic environments.

Commodity-specific information in the Sheepshead Mountain GRA is limited. Sub-surface information is virtually non-existent. Therefore, with the exception of geothermal, diatomite, and fluorite resources, the entire area, rather than specific subareas, has been classified for individual GEM resources (Figure 4-1 and Table 4-1).

The entire Sheepshead Mountain GRA has a low favorability (Class 2) for the occurrence of mercury deposits. Two environments are favorable for geothermal resources. These are located in the southwestern portion of the Sheepshead Mountain GRA. One subarea is higly favorable (Class 4), and the other has a low favorability (Class 2) for geothermal resources. Volcanogenic units that contain significant lacustrine sediments are moderately favorable (Class 3) for the occurrence of diatomite. A very restricted Quaternary alluvial environment has a low favorability (Class 2) for fluorite.

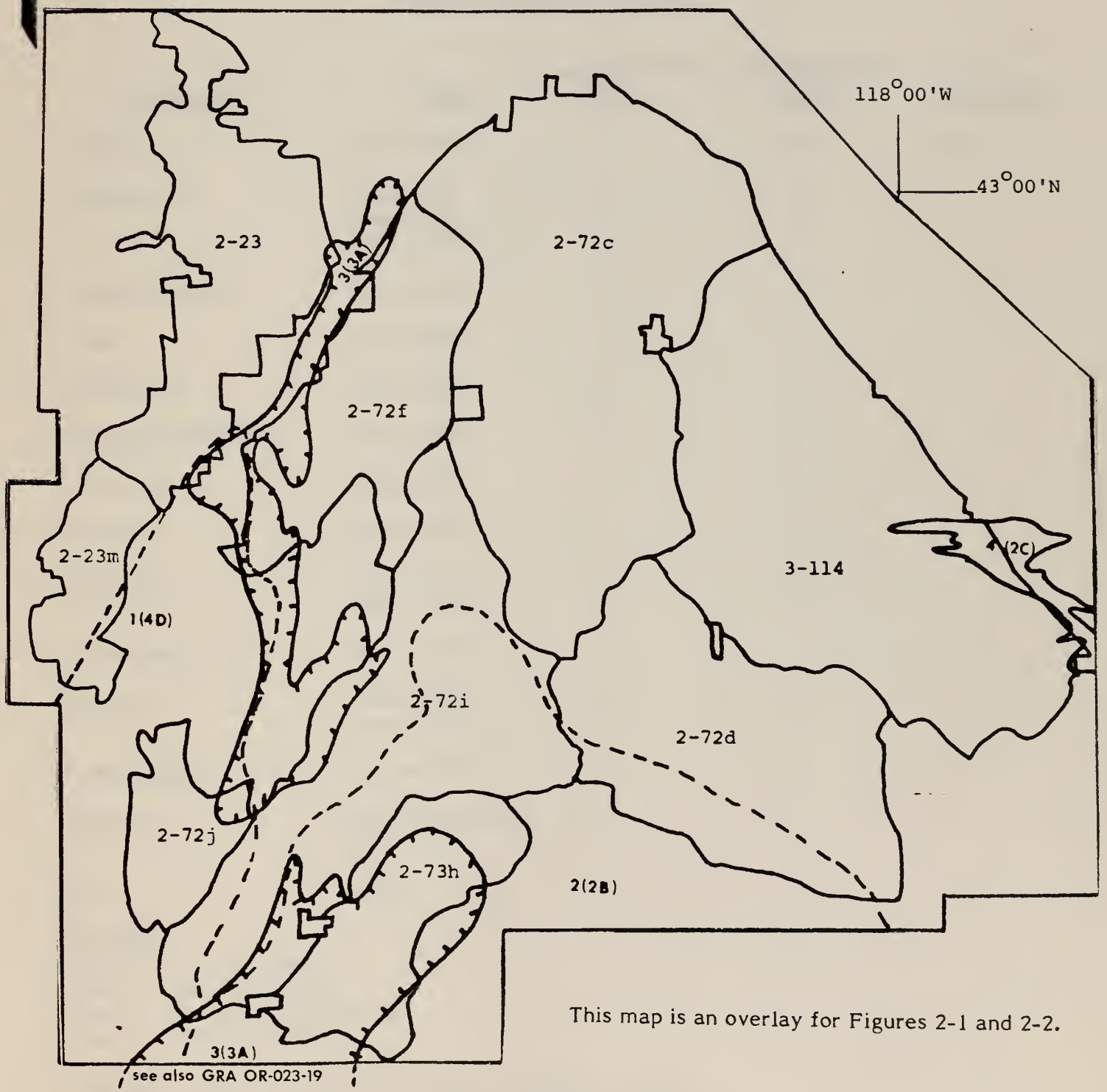
Because of the paucity of detailed, commodity-specific information, the Sheepshead Mountain GRA could not be subdivided into specific areas favorable for most GEM resources. Therefore, the entire Sheepshead Mountain GRA is considered favorable (Class 2) for mercury, coal, oil and gas, bentonite, zeolites, and paleontological resources.

The Sheepshead Mountain GRA does not exhibit characteristics favorable (Class 1) for the occurrence of other GEM resources (Table 4-1).

TERRADATA's classification of geothermal resources potential is in agreement with the prospectively valuable and KGRA assignments given to the area by the USGS[21]. It is also in agreement with the USGS oil and gas potential rating (potentially favorable)[22]. Because of the lack of sub-surface information, TERRADATA did not evaluate the area for sodium salts or borates. The Sheepshead Mountain GRA is classified, in part, as prospectively valuable for sodium by the USGS[23].

FIGURE 4-1

Land Classification Map
Sheepshead Mountain GRA
(OR - 023 - 18)
Harney and Malheur Counties, Oregon



This map is an overlay for Figures 2-1 and 2-2.

Scale 1:250,000
(Jordan Valley, Adel, and Burns 1°x2° NTMS Quadrangle)

TABLE 4-1

Classification Of Lands Within The
Sheepshead Mountain GRA
(OR - 023 - 18)
Harney and Malheur Counties, Oregon
For GEM Resource Potential

COMMODITY	AREA	CLASSIFICATION LEVEL	CONFIDENCE LEVEL	REMARKS
Metals	Entire GRA	2	B	Hg
Geothermal	Area 1-4D	4	D	
	Area 2-2B	2	B	
	Rest of GRA	1	B	
Uranium/Thorium	Entire GRA	1	A	
Coal	Entire GRA	2	C	
Oil and Gas	Entire GRA	3	B	
Tar Sands/Oil Shale	Entire GRA	1	C	
Limestone	Entire GRA	1	B	
Bentonite	Entire GRA	2	A	
Diatomite	Ares 3-3A	3	A	
	Rest of GRA	1	B	
Clinoptilolite	Entire GRA	2	A	
Fluorite	Area 4-2C	2	C	
	Rest of GRA	1	B	
Paleontology	Entire GRA	2	A	
Hazards	See Hazards Map (GRA File)			
ESLs	None	1	C	

LEGEND:
Class 1 - Least Favorable
Class 2 - Low Favorability
Class 3 - Moderate Favorability
Class 4 - High Favorability

Confidence Level A - Insufficient data or no direct evidence
Confidence Level B - Indirect evidence available
Confidence Level C - Direct evidence but quantitatively minimal
Confidence Level D - Abundant direct and indirect evidence

5. RECOMMENDATIONS FOR FUTURE WORK

Further work in the Sheepshead Mountain GRA should be designed to increase the confidence levels of the classifications. Detailed surface investigations should be undertaken for recognition criteria for industrial minerals (e.g., environmental phenomena that might produce bentonite or clinoptilolite; ash flow tuffs with possible basal vitrophyres for perlite, etc.); and for additional metallic deposits (soil chemistry, stream sediment analyses, etc). With the exception of either geophysical investigations or drilling, future work should be confined to detailed mapping, geochemical sampling, and general field exploration. Geochemical samples should be taken from hot springs and hot spring deposits and analyzed for metals.

- APPENDIX A -

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